

AMENDMENT TO THE CLAIMS

Please **CANCEL** claims 1-26 and 49-56.

A copy of all pending claims and a status of the claims are provided below.

1.-26. (cancel)

27. A beam-emission-angle compensating optical unit for correcting a beam emission angle, comprising:

an optical element formed of a light-transmissive member having a refractive index n , including:

a light incident surface receiving an incident light beam in an incident beam direction which is defined with respect to a reference axis; and

a light emitting surface emitting an output light beam in an output beam direction which is defined with respect to the reference axis, the light incident surface and the light emitting surface forming an angle α therebetween and defining an imaginary normal plane, which is orthogonal to both the light incident surface and the light emitting surface and which extends along the reference axis, the output beam direction being shifted by an angle δ from the incident beam direction, the angle δ having a value that depends on the refractive index n , the angle α , and a rotational position of the imaginary normal plane relative to the reference axis.

28. The beam-emission-angle compensating optical unit as claimed in claim 27, wherein the angle α has a value that substantially satisfies an equation $\alpha = \delta / (n - 1)$.

29. The beam-emission-angle compensating optical unit as claimed in claim 28, wherein the reference axis is defined in an xyz space, the xyz space being defined by x-axis, y-axis, and z-axis that are orthogonal to one another, the x-axis and the y-axis defining an xy plane, the x-axis and the z-axis defining an xz plane, and the y-axis and the z-axis defining a

yz plane, the reference axis extending along the x-axis, the incident beam direction being shifted from the x-axis by the angle δ , which defines an angle δ_{yz} between the y-axis and an orthogonal projection component of the incident light beam in the yz plane; and

wherein the optical element is disposed with its imaginary normal plane being located at a rotational angle ϕ from the xy plane around the x-axis, the rotational angle ϕ being equal to the angle δ_{yz} to allow the light emitting surface to output the output light beam in the output beam direction that is parallel with the x axis.

30. The beam-emission-angle compensating optical unit as claimed in claim 27,

wherein the reference axis is defined in an xyz space, the xyz space being defined by x-axis, y-axis, and z-axis that are orthogonal to one another, the x-axis and the y-axis defining an xy plane, the x-axis and the z-axis defining an xz plane, and the y-axis and the z-axis defining a yz plane, the reference axis extending along the x-axis, the incident beam direction being defined by an angle δ_{xy} formed between the x-axis and an orthogonal projection component of the incident light beam in the xy plane and another angle δ_{xz} formed between the x-axis and an orthogonal projection component of the incident light beam in the xz plane,

wherein the optical element includes a first optical element and a second optical element, which are arranged along the reference axis, the first optical element receiving the incident light beam and outputting an intermediate light beam, the second optical element receiving the intermediate light beam and outputting an output light beam,

wherein the first optical element is formed of a light-transmissive member having a refractive index n and including:

a first light incident surface receiving the incident light beam in the incident beam direction; and

a first light emitting surface emitting the intermediate light beam in an intermediate beam direction which is defined with respect to the reference axis, the first light incident surface and the first light emitting surface forming an angle α_1 therebetween, the angle α_1 having a value substantially equal to $\delta_{xy}/(n-1)$, and defining a first imaginary normal plane,

which is orthogonal to both the first light incident surface and the first light emitting surface and which extends along the reference axis,

the first optical element being disposed with the first imaginary normal plane being oriented to extend along the xy plane, thereby outputting the intermediate light beam in the intermediate beam direction that extends parallel to the xz plane;

wherein the second optical element is formed of another light-transmissive member having a refractive index n and including:

a second light incident surface receiving the intermediate light beam in the intermediate beam direction; and

a second light emitting surface emitting the output light beam in the output beam direction which is defined with respect to the reference axis, the second light incident surface and the second light emitting surface forming an angle α_2 therebetween, the angle α_2 having a value substantially equal to $\delta xz/(n-1)$, and defining a second imaginary normal plane, which is orthogonal to both the second light incident surface and the second light emitting surface and which extends along the reference axis,

the second optical element being disposed with the second imaginary normal plane being oriented to extend along the xz plane, thereby outputting the output light beam in the output beam direction that extends parallel to the xy plane, resulting in that the output beam direction extends parallel with the x axis.

31. The beam-emission-angle compensating optical unit as claimed in claim 27, further comprising a holding unit holding the optical element rotatably about the reference axis.

32. The beam-emission-angle compensating optical unit as claimed in claim 31,

wherein the reference axis is defined in an xyz space, the xyz space being defined by x-axis, y-axis, and z-axis that are orthogonal to one another, the x-axis and the y-axis defining an xy plane, the x-axis and the z-axis defining an xz plane, and the y-axis and the z-axis defining a yz plane, the reference axis extending along the z-axis,

the incident beam direction being defined by an angle γ_{1yz} formed between the z-axis and an orthogonal projection component of the incident light beam in the yz plane and by another angle γ_{1xz} formed between the z-axis and an orthogonal projection component of the incident light beam in the xz plane;

wherein the angle α satisfies inequalities:

$$-1 \leq \gamma_{1yz} / ((n-1) \alpha) \leq 1 \quad \text{and} \quad -1 \leq \gamma_{1xz} / ((n-1) \alpha) \leq 1 ,$$

wherein the holding unit orients the imaginary normal plane of the optical element to form a rotational angle ϕ from the yz plane around the z-axis,

wherein the light emitting surface emits the output light beam with an angle β_{yz} defined between the z-axis and an orthogonal projection component of the output light beam in the yz plane and an angle β_{xz} defined between the z-axis and another orthogonal projection component of the output light beam in the xz plane, the angles β_{yz} and β_{xz} satisfying equations:

$$\beta_{yz} = (n-1) \alpha \cdot \cos\phi - \gamma_{1yz} \quad \text{and}$$

$$\beta_{xz} = (n-1) \alpha \cdot \sin\phi - \gamma_{1xz} .$$

33. The beam-emission-angle compensating optical unit as claimed in claim 32, wherein the output beam direction extends parallel with the xz plane where the rotational angle ϕ satisfies an equation of $\beta_{yz} = 0 = (n-1) \alpha \cdot \cos\phi - \gamma_{1yz}$.

34. The beam-emission-angle compensating optical unit as claimed in claim 32, wherein the output beam direction extends parallel with the yz plane where the rotational angle ϕ satisfies an equation of $\beta_{xz} = 0 = (n-1) \alpha \cdot \sin\phi - \gamma_{1xz}$.

35. The beam-emission-angle compensating optical unit as claimed in claim 31,

wherein the reference axis is defined in an xyz space, the xyz space being defined by x-axis, y-axis, and z-axis that are orthogonal to one another, the x-axis and the y-axis define an xy

plane, the x-axis and the z-axis define an xz plane, and the y-axis and the z-axis define a yz plane, the reference axis extending along the z-axis,

the incident beam direction being defined by an angle γ_{1yz} formed between the z-axis and an orthogonal projection component of the incident light beam in the yz plane and by another angle γ_{1xz} formed between the z-axis and an orthogonal projection component of the incident light beam in the xz plane;

wherein the optical element includes a first optical element and a second optical element, which are arranged along the reference axis, the first optical element receiving the incident light beam and outputting an intermediate light beam, the second optical element receiving the intermediate light beam and outputting the output light beam,

wherein the holding unit includes:

a first holding unit holding the first optical element rotatably about the reference axis; and

a second holding unit holding the second optical element rotatably about the reference axis independently from the first optical element,

wherein the first optical element is formed of a light-transmissive member having a refractive index n and including:

a first light incident surface receiving the incident light beam in the incident beam direction; and

a first light emitting surface emitting the intermediate light beam in an intermediate beam direction which is defined with respect to the reference axis, the first light incident surface and the first light emitting surface forming an angle α therebetween and defining a first imaginary normal plane, which is orthogonal to both the first light incident surface and the first light emitting surface and which extends along the reference axis,

wherein the second optical element is formed of another light-transmissive member having a refractive index n and including:

a second light incident surface receiving the intermediate light beam in the intermediate beam direction; and

a second light emitting surface emitting the output light beam in the output beam direction which is defined with respect to the reference axis, the second light incident surface and the second light emitting surface forming the angle α therebetween, and defining a second imaginary normal plane, which is orthogonal to both the second light incident surface and the second light emitting surface and which extends along the reference axis,

wherein the angle α satisfies the inequalities:

$$-2 \leq \gamma_{1_{yz}} / ((n-1) \alpha) \leq 2 \quad \text{and} \quad -2 \leq \gamma_{1_{xz}} / ((n-1) \alpha) \leq 2$$

wherein the first holding unit orients the first imaginary normal plane to form a rotational angle ϕ_1 from the yz plane around the z-axis,

wherein the second holding unit orients the second imaginary normal plane to form a rotational angle ϕ_2 from the yz plane around the z-axis,

wherein the second light emitting surface of the second optical element emits the output light beam with an angle β_{yz} defined between the z-axis and an orthogonal projection component of the output light beam in the yz plane and an angle β_{xz} defined between the z-axis and another orthogonal projection component of the output light beam in the xz plane, the angles β_{yz} and β_{xz} satisfying equations:

$$\begin{aligned} \beta_{yz} &= (n-1) \alpha \cdot (\cos\phi_1 + \cos\phi_2) - \gamma_{1_{yz}} \quad \text{and} \\ \beta_{xz} &= (n-1) \alpha \cdot (\sin\phi_1 + \sin\phi_2) - \gamma_{1_{xz}} \end{aligned}$$

36. The beam-emission-angle compensating optical unit as claimed in claim 35, wherein the output beam direction extends parallel with the z-axis where the rotational angles ϕ_1 and ϕ_2 satisfy equations of:

$$\begin{aligned} \beta_{yz} = 0 &= (n-1) \alpha \cdot (\cos\phi_1 + \cos\phi_2) - \gamma_{1_{yz}} \quad \text{and} \\ \beta_{xz} = 0 &= (n-1) \alpha \cdot (\sin\phi_1 + \sin\phi_2) - \gamma_{1_{xz}} \end{aligned}$$

37. The beam-emission-angle compensating optical unit as claimed in claim 31,

wherein the reference axis is defined in an xyz space, the xyz space being defined by x-axis, y-axis, and z-axis that are orthogonal to one another, the x-axis and the y-axis define an xy plane, the x-axis and the z-axis define an xz plane, and the y-axis and the z-axis define a yz plane, the reference axis extending along the z-axis,

the incident beam direction being defined by an angle γ_{1yz} formed between the z-axis and an orthogonal projection component of the incident light beam in the yz plane and by another angle γ_{1xz} formed between the z-axis and an orthogonal projection component of the incident light beam in the xz plane;

wherein the optical element includes a first optical element and a second optical element, which are arranged along the reference axis, the first optical element receiving the incident light beam and outputting an intermediate light beam, the second optical element receiving the intermediate light beam and outputting the output light beam,

wherein the holding unit includes:

a first holding unit holding the first optical element fixedly about the reference axis; and

a second holding unit holding the second optical element rotatably about the reference axis independently from the first optical element,

wherein the first optical element is formed of a light-transmissive member having a refractive index n and including:

a first light incident surface receiving the incident light beam in the incident beam direction; and

a first light emitting surface emitting the intermediate light beam in an intermediate beam direction which is defined with respect to the reference axis, the first light incident surface and the first light emitting surface forming an angle α therebetween and defining a first imaginary normal plane, which is orthogonal to both the first light incident surface and the first light emitting surface and which extends along the reference axis,

wherein the second optical element is formed of another light-transmissive member having a refractive index n and including:

a second light incident surface receiving the intermediate light beam in the intermediate beam direction; and

a second light emitting surface emitting the output light beam in the output beam direction which is defined with respect to the reference axis, the second light incident surface and the second light emitting surface forming the angle α therebetween, and defining a second imaginary normal plane, which is orthogonal to both the second light incident surface and the second light emitting surface and which extends along the reference axis,

wherein the angle α satisfies the inequalities:

$$0 \leq \gamma_{1yz} / ((n-1) \alpha) \leq 2 \quad \text{and} \quad -1 \leq \gamma_{1xz} / ((n-1) \alpha) \leq 1,$$

wherein the first holding unit orients the first imaginary normal plane to form a rotational angle ϕ_1 of a zero degree (0°) from the yz plane around the z-axis,

wherein the second holding unit orients the second imaginary normal plane to form a rotational angle ϕ_2 from the yz plane around the z-axis,

wherein the second light emitting surface of the second optical element emits the output light beam with an angle β_{yz} defined between the z-axis and an orthogonal projection component of the output light beam in the yz plane and an angle β_{xz} defined between the z-axis and another orthogonal projection component of the output light beam in the xz plane, the angles β_{yz} and β_{xz} satisfying equations:

$$\beta_{yz} = (n-1) \alpha \cdot (1 + \cos\phi_2) - \gamma_{1yz} \quad \text{and}$$

$$\beta_{xz} = (n-1) \alpha \cdot \sin\phi_2 - \gamma_{1xz}.$$

38. The beam-emission-angle compensating optical unit as claimed in claim 37, wherein the output beam direction extends parallel with the xz plane where the rotational angle ϕ_2 satisfies an equation of $\beta_{yz} = 0 = (n-1) \alpha \cdot (1 + \cos\phi_2) - \gamma_{1yz}$.

39. The beam-emission-angle compensating optical unit as claimed in claim 37, wherein the output beam direction extends parallel with the yz plane where the rotational angle φ_2 satisfies an equation of $\beta_{xz} = 0 = (n - 1) \alpha \cdot \sin\varphi_2 - \gamma_{1xz}$.

40. A beam-emission-angle compensating optical unit for correcting a beam emission angle, comprising:

an optical element formed of a light-transmissive member having a refractive index n, including:

a light incident surface receiving an incident light beam in an incident beam direction which is defined with respect to a reference axis; and

a light emitting surface emitting an output light beam in an output beam direction which is defined with respect to the reference axis, the light incident surface and the light emitting surface forming an angle α therebetween, the angle α having a value that depends on the refractive index n.

41. The beam-emission-angle compensating optical unit as claimed in claim 40, wherein the light incident surface and the light emitting surface define an imaginary normal plane, which is orthogonal to both the light incident surface and the light emitting surface and which extends along the reference axis, the incident light direction being shifted from the reference axis with an angle θ , the angle α having a value that substantially satisfies an equation $\alpha = \theta / (n - 1)$ and that allows the output beam direction to be parallel with the reference axis.

42. The beam-emission-angle compensating optical unit as claimed in claim 41, wherein the reference axis extends normal to the light incident surface, and wherein the angle α satisfies an inequality $1.1\theta \leq \alpha \leq 2.2\theta$.

43. The beam-emission-angle compensating optical unit as claimed in claim 41, wherein the reference axis extends normal to the light incident surface, wherein the refractive index n is within a range $1.45 \leq n \leq 1.55$, and the angle α satisfies an equation $\alpha = 2\theta$.

44. A beam-emission-angle compensating optical unit for correcting a beam emission angle, comprising:

a wedge prism formed of a light-transmissive member and including:

a first surface receiving an incident light beam; and

a second surface emitting an output light beam, the first surface and the second surface forming an apex angle α ; and

a holding unit holding the wedge prism such that the wedge prism is capable of rotating about a reference axis, the holding unit holding the wedge prism at a rotational angle about the reference axis from a reference rotational position.

45. The beam-emission-angle compensating optical unit as claimed in claim 44,

wherein the wedge prism includes a first wedge prism and a second wedge prism which are arranged along the reference axis, the first optical element receiving the incident light beam and outputting an intermediate light beam, the second optical element receiving the intermediate light beam and outputting the output light beam; and

wherein the holding unit includes:

a first holding unit holding the first wedge prism; and

a second holding unit holding the second wedge prism.

46. The beam-emission-angle compensating optical unit as claimed in claim 45, wherein the first holding unit holds the first wedge prism such that the first wedge prism can rotate about the reference axis; and wherein the second holding unit holds the second wedge prism such that the second wedge prism can rotate about the reference axis independently from the first wedge prism.

47. The beam-emission-angle compensating optical unit as claimed in claim 45, wherein the first holding unit holds the first wedge prism fixedly at a predetermined rotational position, while the second holding unit holds the second wedge prism such that the second wedge prism can rotate about the reference axis independently from the first wedge prism.

48. The beam-emission-angle compensating optical unit as claimed in claim 45, wherein the reference axis is defined in an xyz space, the xyz space being defined by x-axis, y-axis, and z-axis that are orthogonal to each other; wherein the reference rotational position is defined by the yz plane and the reference axis is the z-axis such that the first and second wedge prisms are disposed at the rotational angles φ_1 and φ_2 around the z-axis respectively from the yz plane; and

wherein the apex angle α satisfies the inequalities:

$$-2 \leq \gamma_{1yz} / ((n-1)\alpha) \leq 2 \quad \text{and} \quad -2 \leq \gamma_{1xz} / ((n-1)\alpha) \leq 2,$$

wherein an angle γ_{1yz} is formed between the z-axis and an orthogonal projection component of the incident light beam in the yz plane, and an angle γ_{1xz} is formed between the z-axis and another orthogonal projection component of the incident light beam in the xz plane, and

wherein the rotational angles φ_1 and φ_2 satisfy equations:

$$\begin{aligned} \beta_{yz} &= (n-1)\alpha \cdot (\cos\varphi_1 + \cos\varphi_2) - \gamma_{1yz} \quad \text{and} \\ \beta_{xz} &= (n-1)\alpha \cdot (\sin\varphi_1 + \sin\varphi_2) - \gamma_{1xz}, \end{aligned}$$

wherein an angle β_{yz} is formed between the z-axis and an orthogonal projection component of the output light beam in the yz plane, and an angle β_{xz} is formed between the z-axis and another orthogonal projection component of the output light beam in the xz plane.

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